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ASSESSMENT OF POPULATION EXPOSURE RISK AND RISK ZONES DUE TO SURFACE WATER QUALITY BY GIS- A CASE STUDY ON SYLHET

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ABSTRACT

A study on the risk assessment due to contaminated surface water system of Sylhet municipality was carried out through analysis of some selected water quality parameters. The parameters considered were Dissolved Oxygen (DO), pH, BOD_5, arsenic (As) and iron (Fe) content of water. The DO concentration of most of the samples were more than 6 mg/l and all the samples have higher values of BOD_5 than 100 mg/l. Fe content of all of the samples were above 0.3 mg/l. About half of the population (47.02%) comes under very bad quality of surface water and it constitutes about 47.28% of total area. Only 30.12% of population is living in the area (31.75%) having medium quality of surface water. Again 22.86% of population is living in the area (20.97%) having bad quality of surface water. About half of the population (55.22%) comes under very high-risk zone.

Keywords: Risk assessment, surface water quality, GIS, exposure index.

INTRODUCTION

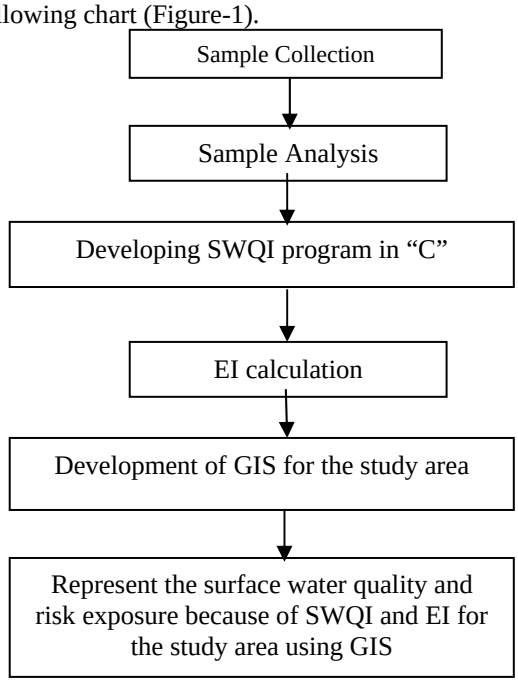
Sylhet, one of the six divisional cities of Bangladesh, is suffering from shortage of domestic water supply. The contamination of arsenic in and around the city has made the use of ground water unsafe [1, 2]. The side of the river Surma situates the Sylhet city. The Kansai River passes from the northern outskirts of the town. It is one of the six divisional cities of Bangladesh. Approximately, 2 million people are at present living in this city that is pertly sewered [3]. The main point source of pollution in the surface water bodies including the river Surma is due to the Pulp and Paper Mill at Chatak, Sunamganj and non-point source discharges from the locality.

It is clear from the analysis of study carried out by Sharma [4] on water quality of river Beas that pH value of water lies between 7.39 and 8.42. The chloride contents range from 28 to 75mg/l. The calcium content varies from 18 to 48 mg/l. In another study Fakayode [5] showed that for Alaro river there was no significant correlation (0.02-0.44) between different parameters (DO/Cl^{-1}, alkalinity/EC, EC/Cl^{-1}, Pb/Cu, Cr/Cu) at upstream whereas they were highly correlated (r^2 = 0.50-0.98) at downstream. Untreated domestic sewage contains pollutants mainly of biodegradable nature, which results in oxygen depletion in surface water [6]. On the other hand, the parameter of highest importance for the state of a surface water body is the concentration of the dissolved oxygen (DO). The most important water quality standards are then related parameters, which affect the oxygen concentration. Therefore, when pollutants entering into a water body are addressed, importance is normally attributed to the concentration of the oxygen consuming substances. Untreated industrial wastes may contain toxic substances. There is no considerable data collection program to identify the present status of pollution in the surface water bodies by Government Organizations or NGO's. Thus an extensive data collection program conducted along the entire municipality over a prolonged period to provide some insight in the present status of pollution.

The study area covered about $11km^2$. There were about 30 industrial units in operation in the locality, mainly, engineering works, paper and pulp, vegetable oils, chemical and steel. This study was initiated for the first time in Sylhet area. The objective of the study was to analyze the quality of surface water and to assess risk associated with surface water quality of Sylhet municipality.

MATERIALS AND METHODS

A detail of working steps is presented in the following chart (Figure-1).



The water samples were collected from different points of Sylhet municipality and tested in the water supply laboratory of the Department of Civil and Environmental Engineering, Shahjalal University of Science and Technology, Sylhet, Bangladesh. The samples were collected, packed and manipulated according to standard sampling method. Iron, Arsenic, pH, Dissolved oxygen and BOD_5 were determined by standard method [7, 8].

Method Adopting for Developing SWQI

The method adopted for calculating water quality index is known as the National Sanitation Foundation Water Quality Index (NSF WQI). The NSF WQI was developed using a formal procedure based on the Rand Corporation's Delphi approach, using a panel of 142 persons from throughout the United States with expertise in various aspects of water quality management [9, 10].

Development of Surface Water Quality Index (SWQI) program in C

With the help of computer program in "C", Surface Water Quality Index (SWQI) of all the areas was calculated. The collected data was entered in the program. The computer output gave the index value with the input data in a separate output file [11] based on the concept developed by Ott [12] and Singh [13].

Calculation of Exposure Index

After getting the values of area, population and SWQI for the 5 zones of Sylhet Municipality, calculation of SWLI, PDI, GRI and Exposure Index (EI) were performed.

Development of GIS for the study area

A Global Information System (GIS) for the study area was developed using ARC/INFO GIS and ARC VIEW GIS software at the GIS Unit situated in Local Government Engineering Department (LGED) Head Office, Agargaon, Dhaka. The map of Sylhet Municipality area was digitized using a digitizer. Using ARC/INFO software, a TIC coverage was created taking raster image as background to establish the real world coordinates i.e. (latitude and longitude) of the study area.

Assessment of Surface Water Quality using GIS

The quality of surface water of different zones has been described by five different categories based on the value of index lying in different ranges by selecting graduated color option in legend editor in ARC VIEW. Five different categories of surface water quality based on the value of index lying in different ranges are given in Table-1.

Table-1. Different category of water based on SWQI value.

Descriptor water quality	Numerical range of index
Very bad	0-10
Bad	11-23
Medium	24-70
Good	71-90
Excellent	91-100

Assessment of Risk Exposure using GIS

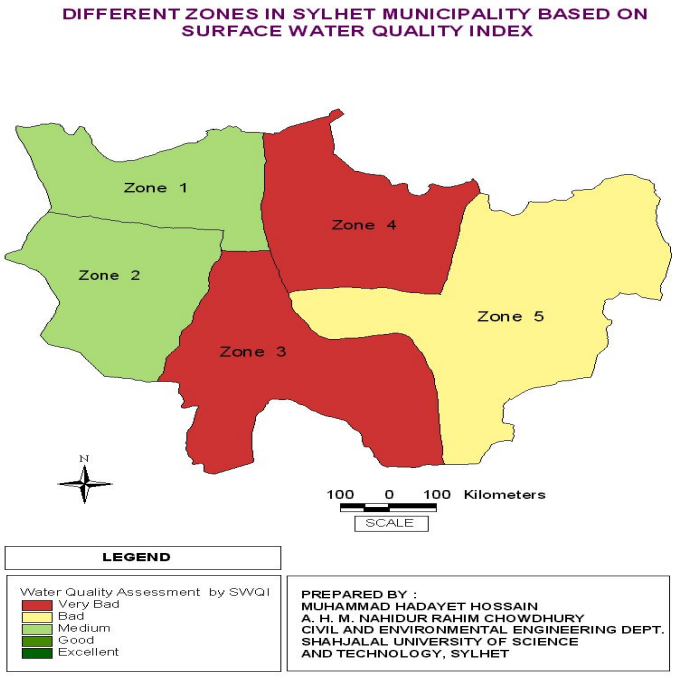
The risk exposure of different zones has been described by five different categories based on the value of exposure index lying in different ranges by selecting graduated color option in legend editor in ARC View. Creating risk zones on the basis of Table-2 has qualitatively assessed the risk exposure.

Table-2. Risk zones lying in different ranges of Exposure Index (EI).

Risk Zones	Numerical range of Exposure Index
Low	0-100
Moderately Low	101-175
Moderately High	176-250
High	251-275
Very High	276-300

RESULTS AND DISCUSSION

Map showing the areas classified in different water quality categories on the basis of Surface Water Quality Index (SWQI) is shown in Figure-2.



Percentage of area and population lying under different categories of surface water quality are shown in the form of pie charts in Figures 3 and 4.

Figure-3. Percentage of area lying under different categories of surface water quality.

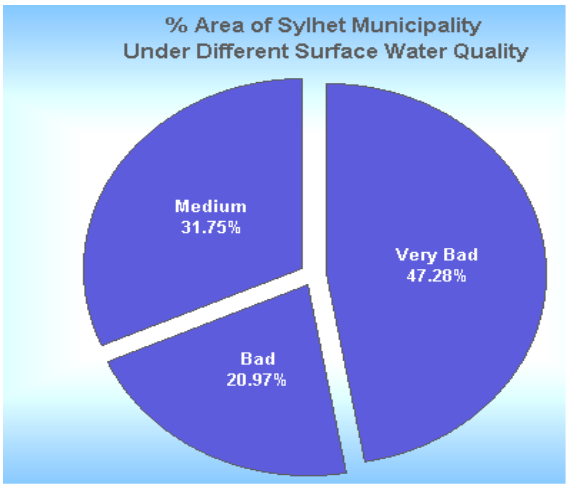
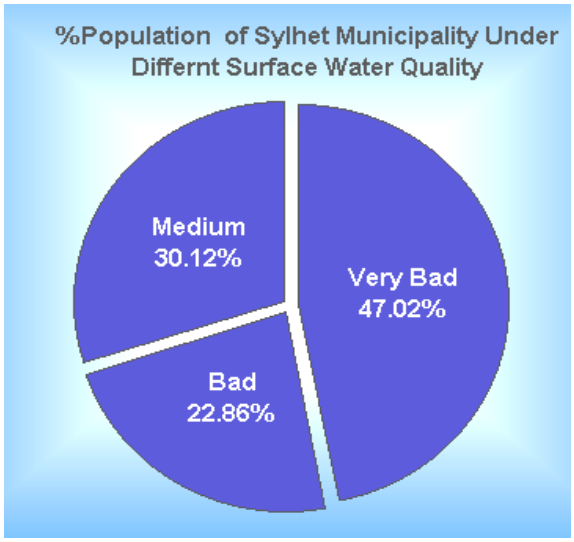
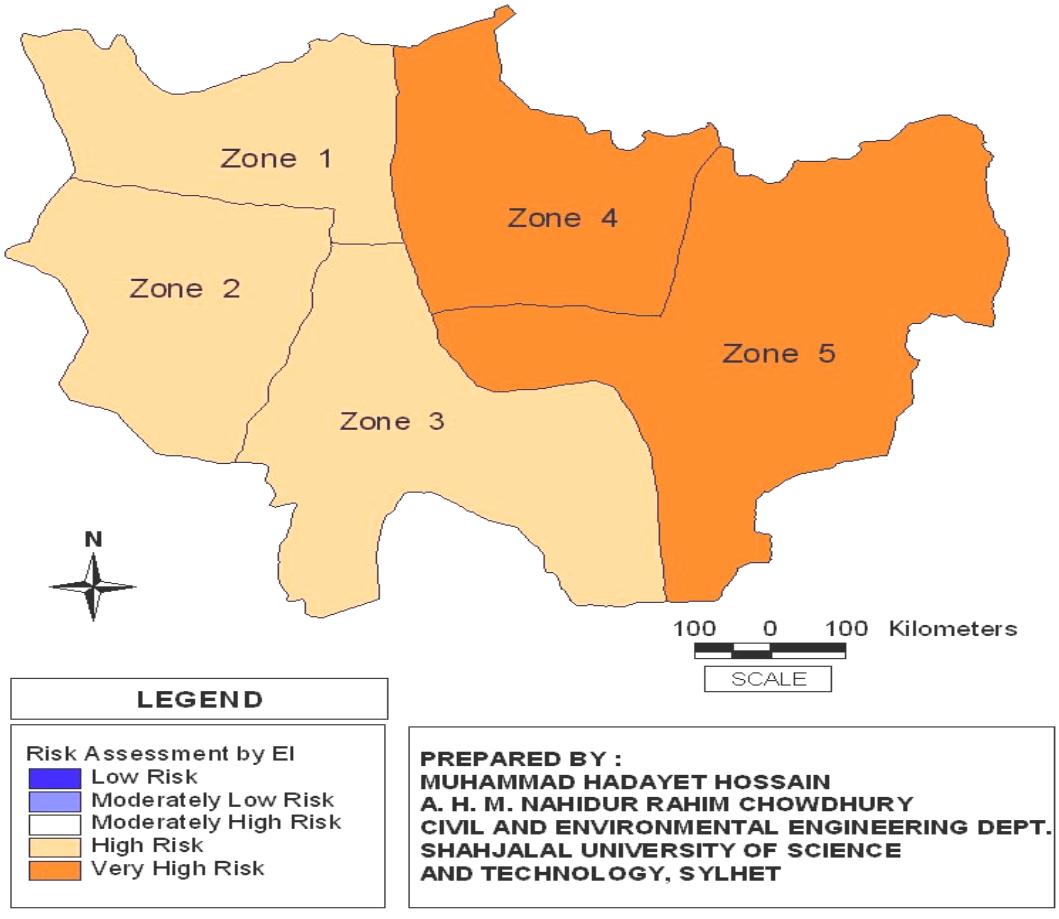


Figure-4. Percentage of population lying under different categories of surface water quality.



Map showing the potential risk zones, which gives qualitative assessment of risk exposure to the inhabitants of the area of interest are shown in Figure-5.

Figure-5. Different risk zones in Sylhet municipality based on Exposure Index.



Percentage of area and population coming under different risk zones are shown in Figures 6 and 7.

Figure-6. Percentage of area lying under different categories of risk zones.

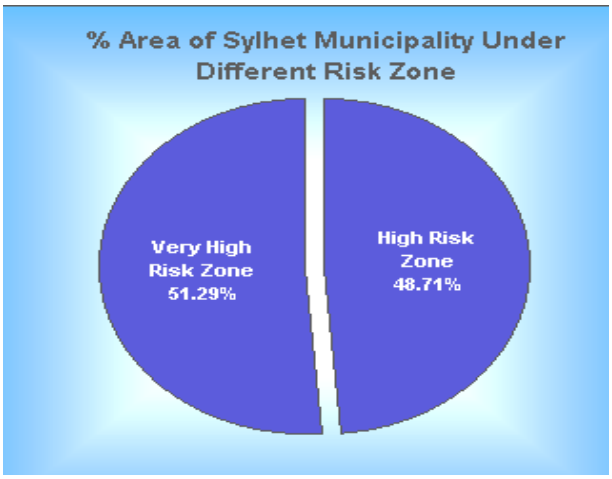
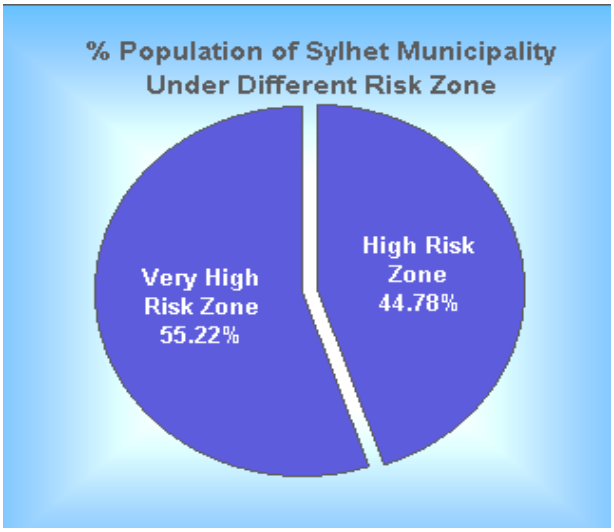


Figure-7. Percentage of population lying under different categories of risk zone.



Following are the salient features of the results presented above:

- From the study it was found that DO (%saturation) of all samples were significant, pH values of all samples were tolerable, BOD_5 values of all samples were high, As content of all samples were much lower than the Bangladesh standard value and Fe content of all the samples were higher than the Bangladesh standard level.
- It is clear from Figure-2 that no area has surface water of excellent quality and at the same time some areas viz. Taltola, Zindabazar, Amborkhana, Hawa para, Mazumdari have very bad quality of surface water. Some areas viz. Baruth Khana, Jharnarpar, Mirabazar have bad quality of surface water. Some areas viz. Dargah Mahallah, Kajal Shah, Subid bazar, Bhatalia, Sekhghat have medium quality of surface water.
- Figures 3 and 4 shows that about half of the population (47.02%) comes under very bad quality of surface water and it constitutes about 47.28% of the total area. Only 30.12% of population is living in the area (31.75%) having medium quality of surface water. Again 22.86% of population is living in the area (20.97%) having bad quality of surface water.
- Figure-5 shows that a considerable part of the concerned area viz. Dargah Mahallah, Kajal Shah, Subid bazar, Bhatalia, Sekhghat, Taltola, Zindabazar is under high-risk zone and some parts viz. Baruth Khana, Jharnarpar, Mirabazar, Amborkhana, Hawa para, Mazumdari come under very high-risk zone.
- Figures 6 and 7 shows that about half of the population (55.22%) comes under very high-risk zone and it constitutes about 51.29% of total area. Again, 44.78% of population is living in the area (48.71%) having high-risk exposure due to existing surface water quality.

CONCLUSION

The study revealed that no area has surface water of excellent quality and at the same time some areas have very bad quality of surface water, some have medium. A considerable part of the study area was under high-risk zone and some parts under very high-risk zone. It was also found that about half of the population (55.22%) comes under very high-risk zone and it constitutes about 51.29% of the total area. Again, 44.78% of population is living in the rest area (48.71%) having high-risk exposure due to existing surface water quality. It can be concluded that if the surface water of Sylhet Municipality is being used as the source of water supply system it should be treated under high degree of treatment.

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